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Development of the Hear Smart Card Sort Noise Assessment Program

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DEVELOPMENT OF THE HEAR SMART CARD SORT NOISE ASSESSMENT PROGRAM

By

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Abstract: The goal of this Capstone Project was to create a web-based application that would allow hearing practitioners to assess and counsel patients on the hazards of past and present occupational and recreational hazardous noise exposure.

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Introduction

Noise induced hearing loss (NIHL) continues to be a tremendous health concern for Americans as risk for occupational and recreational hazardous noise exposure increases in the United States. It is estimated that approximately 36 million American adults have some degree of hearing loss, and approximately 26 million have high frequency hearing loss due to occupational or recreational noise exposure (National Institute on Deafness and Communications Disorders, 2002; Piccirillo, 2011). Approximately 10 million existing cases of hearing loss in the United States have proven to be directly linked to hazardous occupational or recreational noise exposures, thereby proving that the risk for NIHL is not one that is strictly associated with hazardous noise exposure within the workplace, but that which occurs outside of the workplace as well (Griest, Folmer, and Martin, 2007).

Risk for NIHL is highest in occupational environments where workers may be exposed to excessive noise over an 8 hour work-shift (Occupational Safety and Health Administration). The excessive use of powerful equipment and machinery in factories, refineries, industrial facilities, construction sites, mines, and farmlands creates a loud, dynamic environment capable of producing noise levels that may be extremely hazardous to workers, when exposed without proper hearing protection. It is currently estimated that over 4 million Americans are exposed each day to hazardous occupational noise levels, making NIHL one of the leading occupational illnesses in America (National Institute for Occupational Safety and Health, 2010; Piccirillo 2011). The Bureau of Labor Statistics reported that of 59,100 occupational illness cases documented in a survey, 30% resulted from NIHL caused by exposure to excessive hazardous noise on the job (Martinez, 2012). Workers in other industries such as military and aviation may

also be at high risk for hazardous noise exposure. For these industries and occupational environments, use of hearing protection is crucial to workers' safety (Wiatrowski, 2014).

Federal and state regulated hearing conservation programs have helped to successfully reduce risk for occupational NIHL in most industrial environments (Makowsky, 2014). The Department of Labor's Occupational Safety and Health Administration's (OSHA) Noise standard (29 CFR 1910.95) requires employers in industrial companies to have a hearing conservation program in place if workers are exposed to a time-weighted average (TWA) noise level of 85 decibels (dBA) or higher over an 8-hour time frame (Makowsky, 2014). Workers covered by other federal agencies (the Mine Safety and Health Administration, the Federal Aviation Administration, and the Coast Guard) have separate rules. This standard further requires that engineering controls, monitoring, testing, hearing protectors, training and record keeping be incorporated into a standard hearing conservation program to facilitate optimal efficacy (Makowsky, 2014). As a result, the number of compensation claims associated with noise related illnesses, has decreased (National Institute on Occupational Safety and Health, 2010).

While risk for occupational noise exposure may be federally enforced, non-occupational hazardous noise exposure is not. In a recent study, the Centers for Disease Control and Prevention stated "It seems that many Americans are not knowledgeable about sources of hazardous noise at home" (Centers for Disease Control and Prevention, 2014). In this study, the Centers for Disease Control and Prevention reported that 32% of adults say that while they regularly use noisy equipment around the house, they do not believe it could damage their hearing (Centers for Disease Control and Prevention, 2014). Additionally, a survey conducted in 2004 reported that when asked to respond "yes or "no" to the comment, "Listening to my favorite music at very loud levels is potentially harmful to my hearing", only 42% of respondents

replied “yes” leaving 58% of respondents incognizant of the risk of hearing loss from loud music (Griest et al., 2007).

Furthermore, while federal laws regulate occupational noise, laws regulating hazardous noise exposure in non-occupational environments are limited. A few local communities have implemented noise ordinances which regulate times of activity and limit the scope of environmental noises; however these do not account for most recreational activities (Goines, Hagler 2007). There are a number of recreational activities which produce noise levels that can be equally as harmful as occupational noise, for example firearms. Firearms may produce up to 160 dBA of noise, and can cause severe damage to physiological mechanisms of the ear (Civilian Firearms, 2007). Firearms have also been reported as the leading cause of NIHL in America (Civilian Firearms, 2007). It is estimated that approximately 70 million Americans own more than 270 million firearms (Civilian Firearms, 2007). Also, personal audio players (PAPs) (iPods and headphones) may also cause temporary or permanent NIHL if used incorrectly (Levy et al., 2012). Some PAPs produce output levels that exceed 100 dBA. Recent product reviews of the latest “Beats by Dr. Dre” headphones have reported that the headphones produce output levels exceeding 115 dBA at maximum volume (Stamatiou, 2013). In addition to firearms, fireworks, snow mobiles, Go Carts, motorcycles, power horns, model airplanes, and cap guns can also produce hazardous noise levels (Civilian Firearms, 2007). Furthermore, non-recreational activities performed at home may result in hazardous noise exposure. For example, excessive noise exposure to equipment used in landscaping such as a lawn mower (100 dBA), or carpentry work such as a power drill (90 dBA) or chainsaw (120 dBA) may result in NIHL over time (National Institute on Occupational Safety and Health, 2010).

Detection of NIHL continues to be a challenge for hearing practitioners. According to the National Institute for Occupational Safety and Health (NIOSH), "NIHL is 100% preventable" (National Institute on Occupational Safety and Health, 2010). However, because a key characteristic of NIHL is that it occurs as a gradual decline, several years may pass before noise damage is detected in the hearing test (National Institute on Occupational Safety and Health, 2010). Generally, by the time NIHL is detected, the physiological damage to the hearing organs has already been done (Clark and Bohne, 1999; Piccirillo 2011).

Noise exposure does not have to occur in long durations to result in physiological damage to the hearing organs. In fact, short duration exposure can be equally injurious (Clark and Bohne, 1999). High level, short duration exposure exceeding 140 dB (firecracker or high powered rifle) causes acoustic trauma which stretches and then rips or tears the delicate inner ear tissues apart due to mechanical stress to cochlear structures (Clark and Bohne, 1999). Injury to the hearing organs caused by hazardous noise is irreversible (National Institute on Occupational Safety and Health, 2010). According to research, prolonged noise exposure between 90 and 140 dB damages the cochlear metabolically and the degree of damage develops slowly over years and is relative to the degree of loud noise exposure (Clark and Bohne, 1999; Piccirrillo, 2011). Noise injury may cause degeneration of the sensory cells of the organ of Corti, which do not regenerate and are replaced by scar tissue (Clark and Bohne, 1999).

Since both occupational and recreational noise exposure may contribute to NIHL, it is important that hearing practitioners have a method for identifying both forms of noise exposure when evaluating a patient's hearing loss or when counseling for hearing prevention. However, research has proven that patients seem to have difficulty with recalling past events (Baum, Edwards, 2001). Furthermore, when patients think of noisy activities, they seldom consider

recreational noise hazardous, and fail to report exposure to hazardous non occupational noise activities (Centers for Diseases Control and Prevention, 2014). Moreover, hearing practitioners have limited resources to augment patient recall. Few hearing practitioners use techniques to probe patient's memory and have limited time to devote to noise exposure history. For these reasons, noise exposure is often reported based on the patient's recollection at the time, leaving some events forgotten or missed. A more conventional method for assessing past and present noise exposure may resolve some of the difficulty that hearing practitioners currently face when evaluating patients' activities associated with excessive noise.

The Hear Smart Card Sort Noise Assessment Program (HSCSNAP)

An ongoing project in Dr. Jay Piccirillo's lab in the Department of Otolaryngology at Washington University School of Medicine, has been aimed at the development of a card system, modified after the Activity Card Sort (ACS) produced by Carolyn Baum, PhD and Dorothy Edwards, PhD, which assesses activities associated with excessive noise exposure. The Hear Smart Card Sort Noise Assessment Program (HSCSNAP), as it is currently named, would be a measure of occupational and recreational noise exposure in adults. It would allow the hearing practitioner to help adults to recall their past and present occupational, recreational, and leisure activities associated with excessive noise through use of photographs. My project was to automate this idea into a program that could be accessed electronically, hence building an application, and using gamification, videos, and web-based resources to encourage interactivity, while still capturing vital health information.

The Activity Card Sort (ACS)

The strategies utilized in *HSCSNAP* were based on the design of the Activity Card Sort Program (ACS), developed by Carolyn Baum, PhD and Dorothy Edwards, PhD of the Washington University School of Medicine Program in Occupational Therapy. The *ACS* described and documented the individual's retention of his or her own activities utilizing 80 photographs on cards which depicted activities that were instrumental and necessary for the individual to maintain self and property, leisure that do not demand high physical strength or endurance, leisure that require physical endurance and social (Baum, Edwards 2001). The set of cards is placed on the table, and the practitioner and the patient go through each of the cards sorting which tasks the patient participated in before becoming ill (Baum, Edwards 2001). The cards consisted of pictures of actual people performing different activities. The belief is that pictures of individuals actually performing each task may better prompt the adult patient's memory of performing the activity sometime within his or her lifetime (Baum, Edwards 2001). The scoring is done by creating a percentage of activities retained by the patient as an indicator of current occupational engagement. Overall the *ACS* takes approximately 20 minutes to complete.

Although the basis of *ACS* proved to be quite useful for the design of *HSCSNAP*, I found several issues with *ACS* that made its duplication incompatible for hearing practitioners. First, it takes the clinician approximately 20 minutes to complete the *ACS* program with a client. Most hearing practitioners would argue that they do not have much time to dedicate to noise assessment and would prefer to spend 20 minutes completing a full diagnostic test or hearing aid evaluation. Furthermore, there is limited reimbursement for this procedure as Medicare currently does not reimburse for noise assessments. Second, *ACS* requires that the practitioner be present to complete the program. Again, most hearing practitioners would argue that time constraints

may not allow them to be present during the case history. Additional issues include: the photographs on the cards may become boring, or obsolete with time; printing is expensive; and the scoring must be done by hand.

The electronic version of the *HSCSNAP* program would consider the previous issues and provide hearing practitioners with a tool that would decrease the time for completion; eliminate the need to have the practitioner present to complete the assessment; and decrease cost of production.

HSCSNAP Program Design and Features

There are several key elements essential to *HSCSNAP* design. These include: a means of collecting information from individuals regarding their relevant health behaviors; a database or library of photographs and educational materials; a set of decision making rules or algorithms that use the information collected from an individual to create messages tailored to their specific needs; and a method of delivering this information that is clear and understandable to each individual participating in the assessment (Piccirillo, 2011). The combination of these key elements would allow the assessment of exposure to noise and the resultant risk of NIHL, and provide counseling tools, recommendations, and hearing preservation plans to be customized to the participant's needs. The program will consist of a database of occupational and recreational activities associated with loud noise and the associated decibel (dB) level, a library of educational resources related to hazardous noise exposure, NIHL, and hearing protection, games to encourage participant interactivity, and clear printable materials, outlines, and guides. The final step in this project is to create a custom web-application for web-based deployment

available in the form of an iOS app for Apple and Android-based products. The app will be creative and innovative consisting of good content, live, and still videos, sounds, and graphics.

Videos, Gamification, Web-based Resources

Another essential component to *HSCSNAP* design is the use of an original combination of videos, games, and web-based resources. My purpose for integrating these tools was to construct a method of participation that would be fun, interactive, and rewarding to participants; and also cost effective, less time consuming, and helpful to hearing practitioners.

Several studies corroborate the effectiveness of videos, gamification, and web-based resources in assessment, counseling, and education in health care. One study which assessed the effectiveness of video counseling in mental health patients reported high levels of satisfaction and clinical outcomes with video-counseling comparable to in- person counseling (Veder, Beaudoin, Mani, Pope, and Ritchie, 2013). The study's findings reported that when video and in-person counseling sessions were compared, client scores were 8.5 out of 10 ("0" being least helpful; "10" being most helpful) for video and an 8.6 out of 10 for in-person (Veder et al., 2013). Additionally, there was a lower percentage of user withdrawal rate and no shows for video counseling than in-person counseling (Veder et al., 2013).

Moreover, integration of fun activities in the form of health-related games has proven to provide a positive and innovative solution to addressing health problems (Oprescu, Jones, Katskitis, 2014). Games provide a combination of images, sounds, and graphics that allow users to interact in an entertaining way, while still accomplishing a necessary health goal. Recent research has reported that gamification of health-related activities has resulted in improved user engagement and experience with non-game initiatives (Oprescu et. al, 2014). It is asserted that

games engage users by focusing on cognitive, emotional, and social outcomes; providing persuasive elements which encourage participants to explore; learning orientation including knowledge acquisition, skill development and motivational and behavior changes; and achievement based rewards which provide stronger feedback and help build stronger loyalty (Oprescu et al., 2014).

Furthermore, web-based resources provide easy access to educational materials that may be readily accessible almost anywhere. One study assessed the effectiveness of web-based resources in the form of a Multimedia Toolkit where Veteran's Administration (VA) clinic users could easily access desired materials (Luck, Bowman, York, Midboe, Taylor, and Gale, 2014). The study reported that the Toolkit was accessed by 6,745 users in 19 months, thus resulting in nationwide implementation (Luck et al., 2014).

The purpose of this study was to create an electronic version of the *HSCSNAP* that would utilize gamification to make a fun, interactive game; use technology to decrease the amount of time required for completion from 20 minutes to 3-5 minutes; decrease cost of production by going completely electronic; and include an algorithm within the program that allows the computer to perform the scoring automatically. This new automated *HSCSNAP* would make the identification of past and present occupational and recreational noisy activities more efficient.

Methods and Procedures

In this study, a protocol for an electronic version of the Hear Smart Card Sort Noise Assessment Program (HSCSCNAP), was developed to assess past and present exposures to both occupational and recreational noise and the resultant risk of noise-induced hearing loss (NIHL) (See demo in Appendix C).

HSCSNAP User Interface (UI) Design and Interaction

The *HSCSNAP* application was developed using Microsoft Office's Microsoft Visual Studios Express edition 2010. This set of freeware, web development tools allowed utilization of ASP.NET features including drag and drop user interfaces, enhanced HTML code editors, CSS support, JavaScript and XML features. These features were essential because they facilitated the creation of a web-based application with enhanced user interaction and design of a true web based game.

The *HSCSNAP* user interface (UI) was designed in a way that would effectively capture responsiveness, interactivity, important identification and health information without obstructing the Health Insurance Portability and Accountability Act (HIPAA) laws and regulations. Information is stored in the system's database, which is protected by coding and may only be accessed by authorized individuals.

Upon accessing *HSCSNAP*, the user will be prompted to enter his or her name, date of birth, and identification number. Once this information is entered, it is verified by the system's database. Once the information is verified, the user will then be provided with information regarding the terms of *HSCSNAP*, in which the user will either select "Agree to terms" or "Disagree". Upon agreement to terms, the user will be directed to a main menu screen where he or she can select from one of the following options: New User, Returning User, Counseling Tools, Print Report, Options, Help, or Exit. Upon selecting "New User or Returning User", the user will be prompted to a screen which contains a selection of fun, interactive games. Each game is unique and contains its own set of instructions; however the premise of each game is to retrieve as much information about the user's past and present occupational and recreational

activities associated with loud noise, frequency of noise exposure (daily, weekly, monthly, yearly), and duration of noise exposure (1-4 hours, 5-7 hours, 8 or more hours). The *HSCSNAP* consists of a library of over 70 photographs, depicting either an occupational or recreational activity, which are used to preserve the participant's memory of performing the illustrated activity at some point in their lifetime.

Once the game is started, it will prompt the user to answer 5 key questions, to identify his or her past and present occupational and recreational activities associated with loud noise. The first 3 questions will ask: 1.) Which of these tasks resembles what you do at work? 2.) Which of these tasks resembles what you do at home? 3.) Which of these tasks resembles what you do for fun? Each photograph was pre-assigned a decibel level (dBA). A coded algorithm, was already implemented into the application design to determine whether the selected activity presents a hazardous risk of noise exposure or not. In *HSCSNAP*, activities of less than 80 dBA are not considered hazardous; therefore if the user selects an activity that is less than 80 dBA, the photograph will be hidden, and not be included in the average time weighted average (TWA) calculated at the end of the game. Once the user has responded to each of these questions, the selected activities associated with hazardous loud noise will appear on the screen. The user will then be prompted to answer the following questions: "How often do you engage in each activity (daily, weekly, monthly, and yearly)?" and "How long do you engage in each activity (1-4 hours, 5-7 hours, 8 or more hours)?" An algorithm adapted from the Driscoll Sound Dosage Scale will then convert the selected photograph's dBA into TWA and provide an average TWA for all activities reported that exceed 80 dBA (Driscoll, 2010). A database of TWA per activity is also available commercially through the Noise Navigator Sound Level Database by Elliot Berger (Berger, Neitzel, Kladden, 2013). Following questions will include, "For which of these do you

wear hearing protection?" and "Are you interested in wearing hearing protection?" Based on the results an illustration will appear comparing the average TWA without hearing protection versus that with hearing protection to illustrate the possible benefit of hearing protection. It will also show the dose percentage based on reported frequency and duration. The user will then be prompted to wait for the hearing practitioner who will then type in a login code that will allow the user to choose to learn more about hearing protection, view a video demonstration of proper use of hearing protection, access web-based resources on hearing protection and NIHL, view a noise assessment which allows participants to enter in noisy activities and see the decibel level with and without hearing protection, or print his or her report. The printed report will contain a list of the selected activities, the calculated TWA and dose percentage with an explanation of what each score means, specifically to their needs, recommendations for what the user can do to decrease the amount of noise exposure, and references for additional resources. The hearing practitioner will also have access to this report and utilize it to draft his or her own report for the physician or his or her own clinical records.

HSCSNAP Feasibility Survey

Prior to development, I conducted a survey to assess hearing practitioners' technique and success at identifying patients' activities associated with loud noise while evaluating patient's history. Typically, an accurate recollection of noise exposure may be hindered by patient memory, unawareness of which activities actually count as noise exposure, and an imprecise or inconsistent procedure for evaluating patient noise exposure in the patient history. The survey assessed the amount of difficulty that hearing practitioners have while conducting noise exposure assessment as well as the utility of a product or technology that could help to mitigate the challenges that hearing practitioner's face when counseling patients on risk for NIHL.

Participants

The survey was sent to a randomized group of audiologists. A total of 100 responses were collected. Respondents were instructed to answer "yes" or "no" to questions 1-7, and to provide their personal score, a ranking on a scale from 1-10 ("1" being least helpful; "10"-being most helpful) to questions 8-10 when asked their opinion on perceived benefit. Respondents were not asked to reveal any identifying information.

Findings

Survey findings indicated that 100% of audiologists ask their patients about their past and present noise exposure when conducting a case history during a typical appointment. 94% of audiologists reported that they ask their patients about both occupational and recreational activities associated with loud noise when conducting a case history. Although 69.3% of audiologists reported that their patients do not seem to have difficulty with recalling occupational activities associated with loud noise, 62% reported that their patients do seem to have difficulty with recalling recreational activities associated with loud noise. 67% of audiologists reported having adequate resources when counseling patients on noise exposure. Only 15% admitted to utilizing videos and demonstrations, when counseling patients on how to properly wear hearing protection. When asked "How helpful do you think it would be to have a tool that helps patients to better recall their past and present noise exposure on a scale from 1-10 ("1" being least helpful; "10"-being most helpful)?", 77% of audiologists responded a score of 5 or better indicating that there was at least some potential utility. A mean score of 6.41 was recorded. When asked "How helpful do you think it would be to have a tool that identifies both occupational and recreational noisy activities on a scale from 1-10 (1 being least helpful; 10

being most helpful)?", 79% of audiologists responded a score of 5 or better indicating that there was at least some potential utility. A mean score of 6.57 was recorded. When asked, "How helpful do you think it would be to have a tool that assists you with counseling patients on hazardous noise exposure via quick guides, videos, and demonstrations on a scale from 1-10 ("1" being least helpful; "10"-being most helpful)?", 84% of audiologists responded a score of 5 or better indicating that there was some potential utility. A mean score of 7.04 was recorded.

Discussion

There were 3 primary goals for the *HSCSNAP* Feasibility Survey: 1.) To determine whether hearing practitioners are generally concerned about their patients' risk for NIHL 2.) To identify whether hearing practitioners noticed that their patients were having difficulty with recalling occupational and recreational activities associated with loud noise 3.) To identify whether there was a market for a tool that assisted with assessment, and counseling patients on activities associated with loud noise, via videos, demonstrations, and web-based resources. Based on survey results, there were several key findings. One key finding was that all audiologists question their patients about both past and present occupational and recreational activities associated with loud noise. According to the survey results, 100% of audiologists reported that they ask their patients about occupational noise, and 94% reported that they ask their patients about recreational noise. This proves that hearing practitioners are very concerned about their patient's risk for acquiring NIHL in both occupational and recreational settings.

A second key finding from the *HSCSNAP* Feasibility Survey was that most patients seem to have difficulty recalling recreational activities associated with loud noise. While over 90% of audiologists reported that their patients did not seem to have difficulty with understanding that

occupational noise can damage their hearing, over 60% reported that their patients seemed to have difficulty with identifying recreational activities associated with loud noise. Several studies further corroborated this finding including the study by the by the Centers for Disease Control and Prevention and survey conducted in 2004 (Centers for Disease Control and Prevention, 2014; Griest, et al, 2007). Additional studies from other areas of health including physical therapy, psychology, and medicine have also reported patient difficulty with memory recall (Baum, Edwards, 2001). Because patient memory is critical to treatment and intervention of NIHL, it is important to implement strategies that would help trigger patient memory. For this reason, *HSCSNAP* has adopted the *ACS* strategy for recollection incorporating pictures, of both occupational and recreational activities actually being performed into the *HSCSNAP* design, to preserve patient memory.

A third key finding was that there is a strong market for a product or technology that could provide hearing practitioners with assistance when assessing patient exposures to noise and the resultant risk of NIHL. The survey analysis showed a large number and diverse population of audiologists in various work environments deemed the *HSCSNAP* helpful overall. When asked to rate the value of the *HSCSNAP*, 84% of audiologists surveyed gave a score of 5 or better, and an average feasibility score of 6.7 out of 10 (“1” being least helpful; “10” being most helpful) was recorded. It seems that cumulatively, audiologists agree that the incorporation of games, videos, and web-based resources would allow hearing practitioners the tools they need to assess, evaluate, and counsel patients in a way that is cost effective and less time consuming.

Limitations

The *HSCSNAP* was designed to provide hearing practitioners, including audiologists, physicians, Occupational Health and Safety Administration and staff, nurses, and industrial hygienists, with the basic building blocks for assessing patients' exposures to noise and the resultant risk of NIHL, in an innovative way. However, continued effectiveness will be limited by the inability to routinely monitor patients outside of the clinic. While it may be easy to increase patient's knowledge and ensure their understanding during assessment and counseling, monitoring patient's engagement of actual protective strategies outside of the clinic may be difficult (Griest et al., 2007). Inspiring patients' motivation to adopt change will be critical to maintain commitment to protective strategies. Hence, strategies for keeping patients motivated upon leaving the clinic will be crucial in maintaining effectiveness. It may be of further value for *HSCSNAP* developers to seek ways for implementing a good Patient Follow- up Program that allows for continued monitoring and support. Tele-health services may provide hearing professionals with easy access to patients via online forums or chat rooms.

A second limitation to the *HSCSNAP* is inadequate insurance reimbursement. Currently, Medicare does not reimburse for services involving assessment of noise. However, employers of companies where workers may be exposed to loud noise levels may be willing to pay for this service if it complies with the company's hearing conservation protocol. Since the hearing conservation protocol includes education, assessment, monitoring, and evaluation, it may be of value for *HSCSNAP* facilitators to consult with industrial facilities and bill for this service privately.

Future Expansion and Development

Future expansion of *HSCSNAP* may include the development of more games, original content, videos, animations, and resources. Additional expansion may include implementing a tinnitus management program, and incorporation of a participant monitoring program within the application. However, these additions are not a part of the alpha design. The next steps in development of *HSCSNAP* include validation and reliability through testing of human subjects. A goal is to release the developed program for alpha testing in the Department of Otolaryngology at Washington University School of Medicine.

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Glossary

Activity Card Sort	A tool utilized by practitioners to measure occupational function in adult patients post illness.
Asp.net	A server-side Web application framework designed for Web development to produce dynamic Web pages. It was developed by Microsoft to allow programmers to build dynamic web sites, web applications and web services
Audiologist	The primary health-care professional who evaluates, diagnoses, treats, and manages hearing loss and balance disorders in adults and children.
Gamification	The application of typical elements of game playing (e.g., point scoring, competition with others, rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service.
Hazardous noise exposure	Noise exposure that exceeds 85 decibels potentially causing damage to the hearing organs.
Hearing Practitioner	Any practitioner who is certified to perform hearing tests, dispenses hearing aids, or assesses hearing loss.
Hear Smart Card Sort Noise Assessment Program	A tool used to assess and evaluate an individual's past and present occupational and recreational activities associated with

(HSCSNAP)	noise and counsel individuals on the resultant risk.
Health Insurance Portability and Accessibility Act (HIPAA)	The federal law in which the primary goal is to make it easier for people to keep health insurance, protect the confidentiality and security of healthcare information, and help the healthcare industry control administrative costs.
Microsoft Visual Design Studio	An integrated development environment (IDE) from Microsoft used to develop computer programs for Microsoft Windows operating systems.
Multimedia Toolkit	An online repository of ready-to-use tools created by VA clinic staff that physicians, nurses, and other team members may share, download, and adopt in order to more effectively implement Patient-Centered Medical Home (PCMH) principles and improve local performance on VA metrics.
Noise-induced Hearing Loss	Hearing loss caused by exposure to loud noises.
Occupational noise exposure	Exposure to loud noise in occupational environments.
Personal audio player (PAPs)	An electronic device that is capable of storing and playing digital media.
Recreational noise exposure	Exposure to loud noise in non-occupational environments including during home or leisure activities.
Sound Dose Percentage	Noise dose or the percent allowable limit in noise.
Time weighted average (TWA)	The average noise exposure over a specified period of time, typically 8 hours.

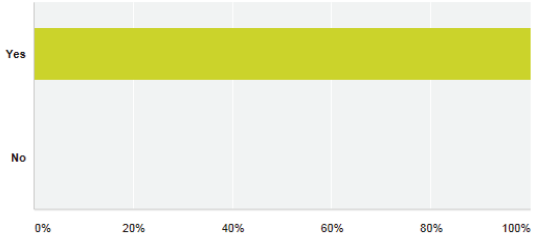
Appendix A

Hear Smart Card Sort Feasibility Survey: Questions, Responses, Analysis

Q1 Customize Export

When conducting a case history, do you ask your patients about their past and present noise exposure?

Answered: 99 Skipped: 1

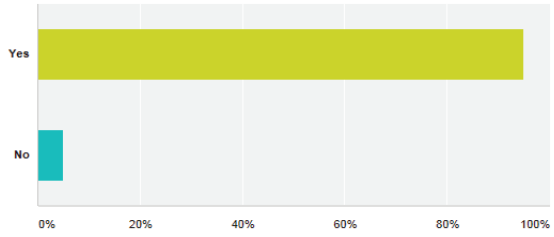


Answer Choices	Responses	
Yes	100%	99
No	0%	0
Total		99

Q2 Customize Export

When conducting a case history, do you ask your patients about BOTH their occupational and recreational noisy activities?

Answered: 99 Skipped: 1



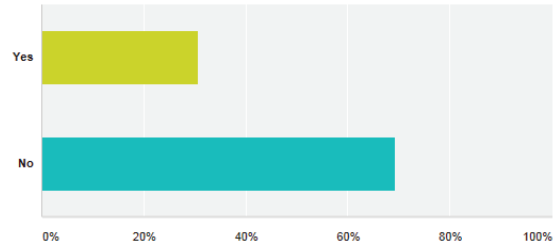
Answer Choices	Responses	
Yes	94.95%	94
No	5.05%	5
Total		99

Q3

Customize Export

When conducting a case history, do your patients seem to have difficulty with recalling occupational noisy activities?

Answered: 98 Skipped: 2



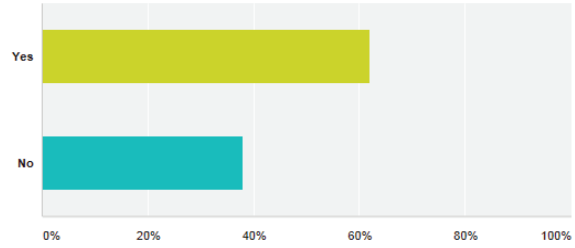
Answer Choices	Responses	
Yes	30.61%	30
No	69.39%	68
Total		98

Q4

Customize Export

When conducting a case history, do your patients seem to have difficulty with recalling recreational noisy activities?

Answered: 100 Skipped: 0

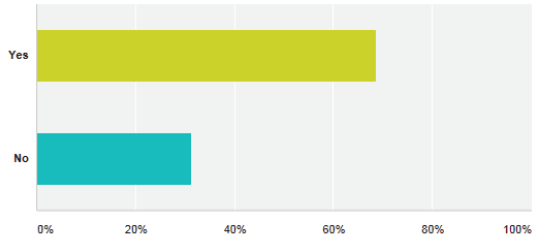


Answer Choices	Responses	
Yes	62%	62
No	38%	38
Total		100

Q5 Customize Export

When counseling your patients on noise exposure, do your patients seem to understand that both occupational and recreational hazardous noise exposure can damage their hearing?

Answered: 99 Skipped: 1

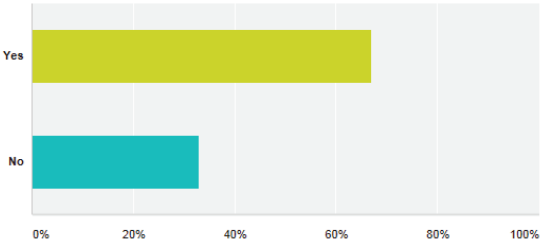


Answer Choices	Responses	
Yes	68.69%	68
No	31.31%	31
Total		99

Q6 Customize Export

When counseling your patients on noise exposure, do you feel that you have adequate resources?

Answered: 100 Skipped: 0

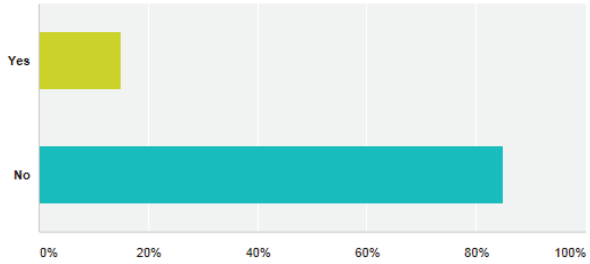


Answer Choices	Responses	
Yes	67%	67
No	33%	33
Total		100

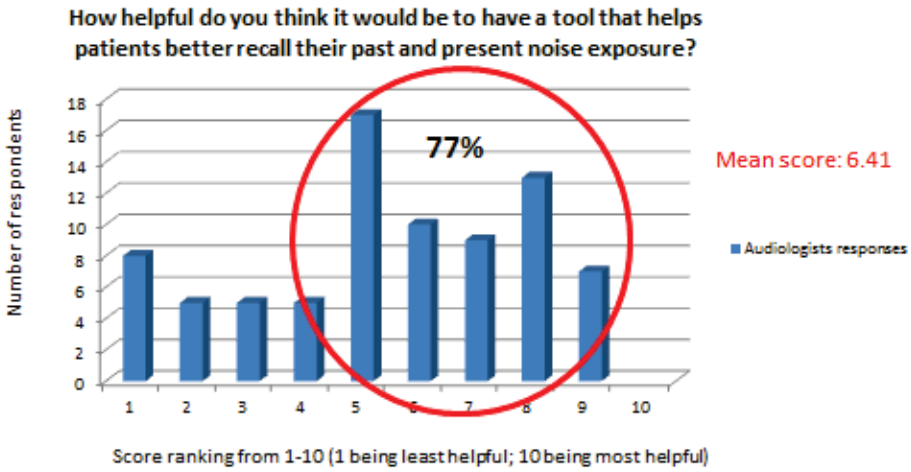
Q7 Customize Export

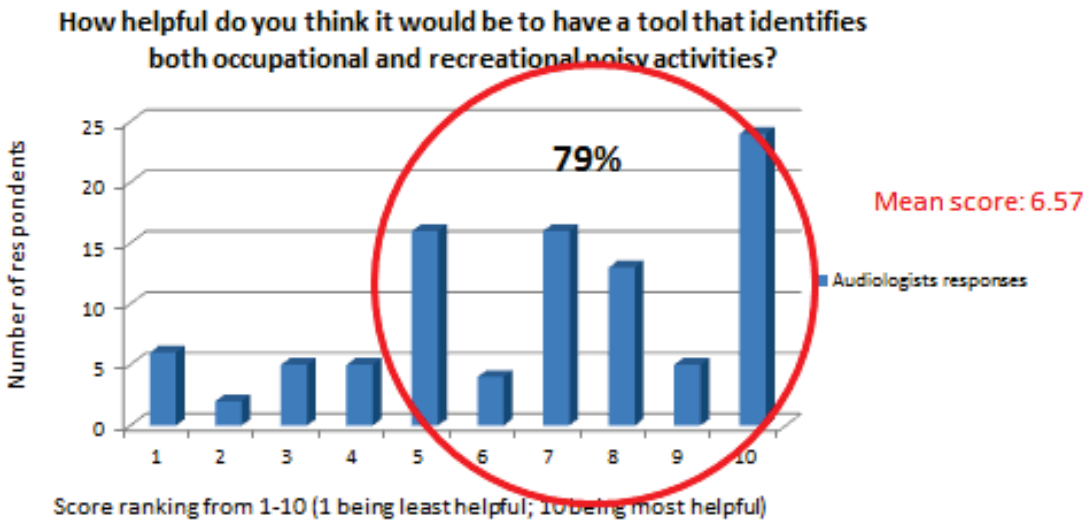
When counseling your patients on noise exposure, do you utilize videos and demonstrations of how to properly wear hearing protection?

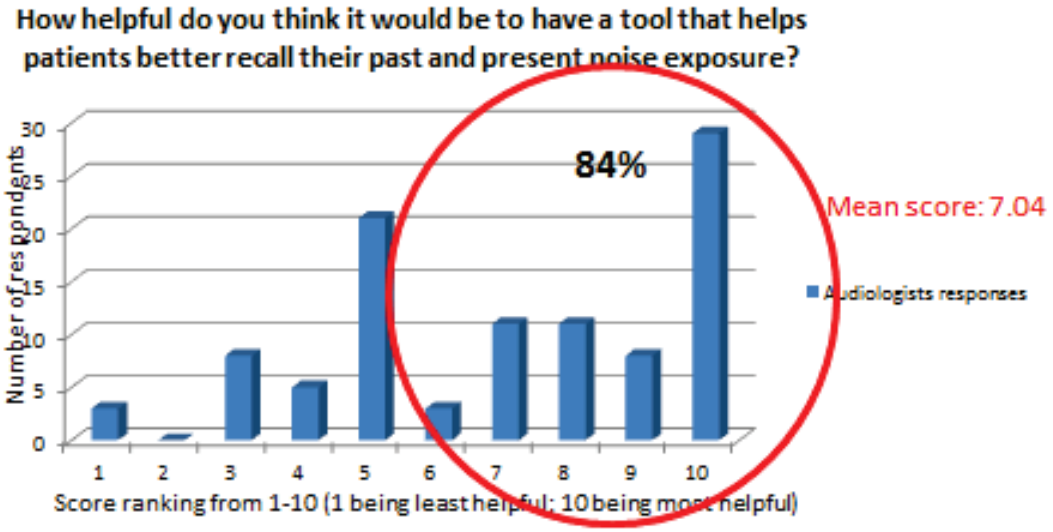
Answered: 100 Skipped: 0



Answer Choices	Responses	
Yes	15%	15
No	85%	85
Total		100




How helpful do you think it would be to have a tool that identifies both occupational and recreational noisy activities?
Number of respondents
25
20
15
10
5
0
79%
Mean score: 6.57
Audiologists responses
1
2
3
4
5
6
7
8
9
10
Score ranking from 1-10 (1 being least helpful; 10 being most helpful)


How helpful do you think it would be to have a tool that helps patients better recall their past and present noise exposure?
Number of respondents
30
25
20
15
10
5
0
84%
Mean score: 7.04
Audiologists responses
1
2
3
4
5
6
7
8
9
10
Score ranking from 1-10 (1 being least helpful; 10 being most helpful)

Appendix B

HSCSNAP TWA based on Driscoll Scale Calculations

(1-4 hours without Hearing Protection)

Noisy Activity	Sound level dBA	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	240	51200	51200	**135.0**
Air conditioner	75	240	0	0	**0.0**
Ambulance siren	120	240	3200	3200	**115.0**
Backhoe	95	240	100	100	**90.0**
Belt sander	97	240	131.95	131.95	**92.0**
Blow dryer	95	240	100	100	**90.0**
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	240	459.48	459.48	**101.0**
Bomb/ grenade blast	191	240	60224876.31	60224876.31	**186.0**
Car horn	110	240	800	800	**105.0**
Car stereo	65	240	0	0	**0.0**
Car wash at 20 feet	89	240	43.52752816	43.52752816	**84.0**
Casino	80	240	12.5	12.5	**75.0**
CD Player on high	112	240	1055.606329	1055.606329	**107.0**
Chainsaw	120	240	3200	3200	**115.0**
Circular saw	100	240	200	200	**95.0**
City traffic	85	240	25	25	**80.0**
Conversation in a restaurant	60	240	0	0	**0.0**
Diesel train at 45 mph at 100 feet	83	240	18.946457 08	18.946457 08	**78.0**
Diesel truck going 40 mph at 50 feet	84	240	21.763764 08	21.763764 08	**79.0**
Dishwasher	80	240	12.5	12.5	**75.0**
Door bell	85	240	25	25	**80.0**
Drills	90	240	50	50	**85.0**
Drums	135	240	25600	25600	**130.0**

Dump truck	85	240	25	25	**80.0**
Electric drill	102	240	263.9015822	263.9015822	**97.0**
Electric shaver	80	240	12.5	12.5	**75.0**
Factory machinery	90	240	50	50	**85.0**
Farm tractor	100	240	200	200	**95.0**
Firecracker	150	240	204800	204800	**145.0**
Fireworks	162	240	1080940.881	1080940.881	**157.0**
Fire engine siren	120	240	3200	3200	**115.0**
Food blender	88	240	37.89291416	37.89291416	**83.0**
Football game	117	240	2111.212657	2111.212657	**112.0**
Freight train at 15 meters	80	240	12.5	12.5	**75.0**
Front end loader	95	240	100	100	**90.0**
Garbage disposal	80	240	12.5	12.5	**75.0**
Garbage truck	100	240	200	200	**95.0**
Grinders	97	240	131.9507911	131.9507911	**92.0**
Gunshot	140	240	51200	51200	**135.0**
Handgun	166	240	1882027.385	1882027.385	**161.0**
Helicopter at 100 feet	100	240	200	200	**95.0**
Jackhammer	100	240	200	200	**95.0**
Jet take-off at 25 meters	150	240	204800	204800	**145.0**
Jet take-off at 305 meters	100	240	200	200	**95.0**
Lawn mower	100	240	200	200	**95.0**
Leaf blower	115	240	1600	1600	**110.0**
Live rock music concert	114	240	1392.880901	1392.880901	**109.0**
Marching band	130	240	12800	12800	**125.0**
Maximum IPOD volume	115	240	1600	1600	**110.0**
Military jet aircraft take-off from aircraft carrier with afterburner at 50 feet	130	240	12800	12800	**125.0**
Milling machine	85	240	25	25	**80.0**
Mine blasting	140	240	51200	51200	**135.0**
Motorcycle	100	240	200	200	**95.0**
Motorcycle at 25 feet	90	240	50	50	**85.0**
MRI	95	240	100	100	**90.0**

Newspaper press	97	240	131.9507911	131.9507911	**92.0**
Night club	110	240	800	800	**105.0**
Oxygen torch	121	240	3675.834736	3675.834736	**116.0**
Pavers	102	240	263.9015822	263.9015822	**97.0**
Piano practice	80	240	12.5	12.5	**75.0**
Plumber	90	240	50	50	**85.0**
Pneumatic breakers	111	240	918.958684	918.958684	**106.0**
Power mower	96	240	114.8698355	114.8698355	**91.0**
Professional DJ System	130	240	12800	12800	**125.0**
Race car drive by	147	240	135117.6101	135117.6101	**142.0**
Refrigerator	50	240	0	0	**0.0**
Rifle	163	240	1241675.011	1241675.011	**158.0**
Riveting machine	110	240	800	800	**105.0**
Rock and roll concert	120	240	3200	3200	**115.0**
Scrapers	102	240	263.9015822	263.9015822	**97.0**
Sewing machine	60	240	0	0	**0.0**
Shotgun blast	140	240	51200	51200	**135.0**
Subway	115	240	1600	1600	**110.0**
Symphony orchestra	110	240	800	800	**105.0**
Traffic	85	240	25	25	**80.0**
Turbo fan aircraft at take-off power at 200 feet	118	240	2425.146506	2425.146506	**113.0**
Vacuum cleaner	70	240	0	0	**0.0**
Washing machine	75	240	0	0	**0.0**

(1-4 hours with Hearing Protection NRR 33)

Noisy Activity	Sound level Dba	Hearing Protection with NRR	Sound level dBA with HP	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	33	107	240	527.8031643	527.8031643	**102.0**
Air conditioner	75	33	42	240	0	0	**0.0**
Ambulance siren	120	33	87	240	32.98769777	32.98769777	**82.0**
Backhoe	95	33	62	240	0	0	**0.0**
Belt sander	97	33	64	240	0	0	**0.0**
Blow dryer	95	33	62	240	0	0	**0.0**
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	33	73	240	0	0	**0.0**
Bomb/ grenade blast	191	33	158	240	620837.5056	620837.5056	**153.0**
Car horn	110	33	77	240	0	0	**0.0**
Car stereo	65	33	32	240	0	0	**0.0**
Car wash at 20 feet	89	33	56	240	0	0	**0.0**
Casino	80	33	47	240	0	0	**0.0**
CD Player on high	112	33	79	240	0	0	**0.0**
Chainsaw	120	33	87	240	32.98769777	32.98769777	**82.0**
Circular saw	100	33	67	240	0	0	**0.0**
City traffic	85	33	52	240	0	0	**0.0**
Conversation in a restaurant	60	33	27	240	0	0	**0.0**
Diesel train at 45 mph at 100 feet	83	33	50	240	0	0	**0.0**
Diesel truck going 40 mph at 50 feet	84	33	51	240	0	0	**0.0**
Dishwasher	80	33	47	240	0	0	**0.0**
Door bell	85	33	52	240	0	0	**0.0**
Drills	90	33	57	240	0	0	**0.0**
Drums	135	33	102	240	263.90158	263.90158	**97.0**

					22	22	
Dump truck	85	33	52	240	0	0	**0.0**
Electric drill	102	33	69	240	0	0	**0.0**
Electric shaver	80	33	47	240	0	0	**0.0**
Factory machinery	90	33	57	240	0	0	**0.0**
Farm tractor	100	33	67	240	0	0	**0.0**
Firecracker	150	33	117	240	2111.212657	2111.212657	**112.0**
Fireworks	162	33	129	240	11143.04721	11143.04721	**124.0**
Fire engine siren	120	33	87	240	32.98769777	32.98769777	**82.0**
Food blender	88	33	55	240	0	0	**0.0**
Football game	117	33	84	240	21.76376408	21.76376408	**79.0**
Freight train at 15 meters	80	33	47	240	0	0	**0.0**
Front end loader	95	33	62	240	0	0	**0.0**
Garbage disposal	80	33	47	240	0	0	**0.0**
Garbage truck	100	33	67	240	0	0	**0.0**
Grinders	97	33	64	240	0	0	**0.0**
Gunshot	140	33	107	240	527.8031643	527.8031643	**102.0**
Handgun	166	33	133	240	19401.17205	19401.17205	**128.0**
Helicopter at 100 feet	100	33	67	240	0	0	**0.0**
Jackhammer	100	33	67	240	0	0	**0.0**
Jet take-off at 25 meters	150	33	117	240	2111.212657	2111.212657	**112.0**
Jet take-off at 305 meters	100	33	67	240	0	0	**0.0**
Lawn mower	100	33	67	240	0	0	**0.0**
Leaf blower	115	33	82	240	16.49384888	16.49384888	**77.0**
Live rock music concert	114	33	81	240	14.35872944	14.35872944	**76.0**
Marching band	130	33	97	240	131.9507911	131.9507911	**92.0**
Maximum IPOD volume	115	33	82	240	16.49384888	16.49384888	**77.0**
Military jet	130	33	97	240	131.95079	131.95079	**92.0**

aircraft take-off from aircraft carrier with afterburner at 50 feet					11	11	
Milling machine	85	33	52	240	0	0	**0.0**
Mine blasting	140	33	107	240	527.8031643	527.8031643	**102.0**
Motorcycle	100	33	67	240	0	0	**0.0**
Motorcycle at 25 feet	90	33	57	240	0	0	**0.0**
MRI	95	33	62	240	0	0	**0.0**
Newspaper press	97	33	64	240	0	0	**0.0**
Night club	110	33	77	240	0	0	**0.0**
Oxygen torch	121	33	88	240	37.89291416	37.89291416	**83.0**
Pavers	102	33	69	240	0	0	**0.0**
Piano practice	80	33	47	240	0	0	**0.0**
Plumber	90	33	57	240	0	0	**0.0**
Pneumatic breakers	111	33	78	240	0	0	**0.0**
Power mower	96	33	63	240	0	0	**0.0**
Professional DJ System	130	33	97	240	131.9507911	131.9507911	**92.0**
Race car drive by	147	33	114	240	1392.880901	1392.880901	**109.0**
Refrigerator	50	33	17	240	0	0	**0.0**
Rifle	163	33	130	240	12800	12800	**125.0**
Riveting machine	110	33	77	240	0	0	**0.0**
Rock and roll concert	120	33	87	240	32.98769777	32.98769777	**82.0**
Scrapers	102	33	69	240	0	0	**0.0**
Sewing machine	60	33	27	240	0	0	**0.0**
Shotgun blast	140	33	107	240	527.8031643	527.8031643	**102.0**
Subway	115	33	82	240	16.49384888	16.49384888	**77.0**
Symphony orchestra	110	33	77	240	0	0	**0.0**
Traffic	85	33	52	240	0	0	**0.0**
Turbo fan	118	33	85	240	25	25	**80.0**

aircraft at take-off power at 200 feet							
Vacuum cleaner	70	33	37	240	0	0	**0.0**
Washing machine	75	33	42	240	0	0	**0.0**

(5-7 hours without Hearing Protection)

Noisy Activity	Sound level dBA	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	420	89600	89600	**139.0**
Air conditioner	75	420	0	0	**0.0**
Ambulance siren	120	420	5600	5600	**119.0**
Backhoe	95	420	175	175	**94.0**
Belt sander	97	420	230.9138844	230.9138844	**96.0**
Blow dryer	95	420	175	175	**94.0**
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	420	804.0888485	804.0888485	**105.0**
Bomb/ grenade blast	191	420	105393533.6	105393533.6	**190.0**
Car horn	110	420	1400	1400	**109.0**
Car stereo		420	0	0	**0.0**
Car wash at 20 feet	89	420	76.17317429	76.17317429	**88.0**
Casino	80	420	21.875	21.875	**79.0**
CD Player on high	112	420	1847.311075	1847.311075	**111.0**
Chainsaw	120	420	5600	5600	**119.0**
Circular saw	100	420	350	350	**99.0**
City traffic	85	420	43.75	43.75	**84.0**
Conversation in a restaurant	60	420	0	0	**0.0**
Diesel train at 45 mph at 100 feet	83	420	33.15629989	33.15629989	**82.0**
Diesel truck going 40 mph at 50 feet	84	420	38.08658714	38.08658714	**83.0**
Dishwasher	80	420	21.875	21.875	**79.0**
Door bell	85	420	43.75	43.75	**84.0**
Drills	90	420	87.5	87.5	**89.0**
Drums	135	420	44800	44800	**134.0**

Dump truck	85	420	43.75	43.75	**84.0**
Electric drill	102	420	461.8277688	461.8277688	**101.0**
Electric shaver	80	420	21.875	21.875	**79.0**
Factory machinery	90	420	87.5	87.5	**89.0**
Farm tractor	100	420	350	350	**99.0**
Firecracker	150	420	358400	358400	**149.0**
Fireworks	162	420	1891646.541	1891646.541	**161.0**
Fire engine siren	120	420	5600	5600	**119.0**
Food blender	88	420	66.31259978	66.31259978	**87.0**
Football game	117	420	3694.62215	3694.62215	**116.0**
Freight train at 15 meters	80	420	21.875	21.875	**79.0**
Front end loader	95	420	175	175	**94.0**
Garbage disposal	80	420	21.875	21.875	**79.0**
Garbage truck	100	420	350	350	**99.0**
Grinders	97	420	230.9138844	230.9138844	**96.0**
Gunshot	140	420	89600	89600	**139.0**
Handgun	166	420	3293547.923	3293547.923	**165.0**
Helicopter at 100 feet	100	420	350	350	**99.0**
Jackhammer	100	420	350	350	**99.0**
Jet take-off at 25 meters	150	420	358400	358400	**149.0**
Jet take-off at 305 meters	100	420	350	350	**99.0**
Lawn mower	100	420	350	350	**99.0**
Leaf blower	115	420	2800	2800	**114.0**
Live rock music concert	114	420	2437.541577	2437.541577	**113.0**
Marching band	130	420	22400	22400	**129.0**
Maximum IPOD volume	115	420	2800	2800	**114.0**
Military jet aircraft take-off from aircraft carrier with afterburner at 50 feet	130	420	22400	22400	**129.0**
Milling machine	85	420	43.75	43.75	**84.0**
Mine blasting	140	420	89600	89600	**139.0**
Motorcycle	100	420	350	350	**99.0**
Motorcycle at 25	90	420	87.5	87.5	**89.0**

feet					
MRI	95	420	175	175	**94.0**
Newspaper press	97	420	230.9138844	230.9138844	**96.0**
Night club	110	420	1400	1400	**109.0**
Oxygen torch	121	420	6432.710788	6432.710788	**120.0**
Pavers	102	420	461.8277688	461.8277688	**101.0**
Piano practice	80	420	21.875	21.875	**79.0**
Plumber	90	420	87.5	87.5	**89.0**
Pneumatic breakers	111	420	1608.177697	1608.177697	**110.0**
Power mower	96	420	201.0222121	201.0222121	**95.0**
Professional DJ System	130	420	22400	22400	**129.0**
Race car drive by	147	420	236455.8176	236455.8176	**146.0**
Refrigerator	50	420	0	0	**0.0**
Rifle	163	420	2172931.27	2172931.27	**162.0**
Riveting machine	110	420	1400	1400	**109.0**
Rock and roll concert	120	420	5600	5600	**119.0**
Scrapers	102	420	461.8277688	461.8277688	**101.0**
Sewing machine	60	420	0	0	**0.0**
Shotgun blast	140	420	89600	89600	**139.0**
Subway	115	420	2800	2800	**114.0**
Symphony orchestra	110	420	1400	1400	**109.0**
Traffic	85	420	43.75	43.75	**84.0**
Turbo fan aircraft at take-off power at 200 feet	118	420	4244.006386	4244.006386	**117.0**
Vacuum cleaner	70	420	0	0	**0.0**
Washing machine	75	420	0	0	**0.0**

(5-7 hours with Hearing Protection NRR 33)

Noisy Activity	Sound level dBA	Hearing Protection with NRR	Sound level dBA with HP	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	33	107	420	923.6555375	923.6555375	**106.0**

Air conditioner	75	33	42	420	0	0	**0.0**
Ambulance siren	120	33	87	420	57.7284711	57.7284711	**86.0**
Backhoe	95	33	62	420	0	0	**0.0**
Belt sander	97	33	64	420	0	0	**0.0**
Blow dryer	95	33	62	420	0	0	**0.0**
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	33	73	420	0	0	**0.0**
Bomb/ grenade blast	191	33	158	420	1086465.635	1086465.635	**157.0**
Car horn	110	33	77	420	0	0	**0.0**
Car stereo		33	-33	420	0	0	**0.0**
Car wash at 20 feet	89	33	56	420	0	0	**0.0**
Casino	80	33	47	420	0	0	**0.0**
CD Player on high	112	33	79	420	0	0	**0.0**
Chainsaw	120	33	87	420	57.7284711	57.7284711	**86.0**
Circular saw	100	33	67	420	0	0	**0.0**
City traffic	85	33	52	420	0	0	**0.0**
Conversation in a restaurant	60	33	27	420	0	0	**0.0**
Diesel train at 45 mph at 100 feet	83	33	50	420	0	0	**0.0**
Diesel truck going 40 mph at 50 feet	84	33	51	420	0	0	**0.0**
Dishwasher	80	33	47	420	0	0	**0.0**
Door bell	85	33	52	420	0	0	**0.0**
Drills	90	33	57	420	0	0	**0.0**
Drums	135	33	102	420	461.8277688	461.8277688	**101.0**
Dump truck	85	33	52	420	0	0	**0.0**
Electric drill	102	33	69	420	0	0	**0.0**
Electric shaver	80	33	47	420	0	0	**0.0**
Factory machinery	90	33	57	420	0	0	**0.0**
Farm tractor	100	33	67	420	0	0	**0.0**
Firecracker	150	33	117	420	3694.6221	3694.6221	**116.0**

					5	5	
Fireworks	162	33	129	420	19500.33262	19500.33262	**128.0**
Fire engine siren	120	33	87	420	57.7284711	57.7284711	**86.0**
Food blender	88	33	55	420	0	0	**0.0**
Football game	117	33	84	420	38.08658714	38.08658714	**83.0**
Freight train at 15 meters	80	33	47	420	0	0	**0.0**
Front end loader	95	33	62	420	0	0	**0.0**
Garbage disposal	80	33	47	420	0	0	**0.0**
Garbage truck	100	33	67	420	0	0	**0.0**
Grinders	97	33	64	420	0	0	**0.0**
Gunshot	140	33	107	420	923.6555375	923.6555375	**106.0**
Handgun	166	33	133	420	33952.05109	33952.05109	**132.0**
Helicopter at 100 feet	100	33	67	420	0	0	**0.0**
Jackhammer	100	33	67	420	0	0	**0.0**
Jet take-off at 25 meters	150	33	117	420	3694.62215	3694.62215	**116.0**
Jet take-off at 305 meters	100	33	67	420	0	0	**0.0**
Lawn mower	100	33	67	420	0	0	**0.0**
Leaf blower	115	33	82	420	28.86423555	28.86423555	**81.0**
Live rock music concert	114	33	81	420	25.12777652	25.12777652	**80.0**
Marching band	130	33	97	420	230.9138844	230.9138844	**96.0**
Maximum IPOD volume	115	33	82	420	28.86423555	28.86423555	**81.0**
Military jet aircraft take-off from aircraft carrier with afterburner at 50 feet	130	33	97	420	230.9138844	230.9138844	**96.0**
Milling machine	85	33	52	420	0	0	**0.0**
Mine blasting	140	33	107	420	923.6555375	923.6555375	**106.0**

Motorcycle	100	33	67	420	0	0	**0.0**
Motorcycle at 25 feet	90	33	57	420	0	0	**0.0**
MRI	95	33	62	420	0	0	**0.0**
Newspaper press	97	33	64	420	0	0	**0.0**
Night club	110	33	77	420	0	0	**0.0**
Oxygen torch	121	33	88	420	66.31259978	66.31259978	**87.0**
Pavers	102	33	69	420	0	0	**0.0**
Piano practice	80	33	47	420	0	0	**0.0**
Plumber	90	33	57	420	0	0	**0.0**
Pneumatic breakers	111	33	78	420	0	0	**0.0**
Power mower	96	33	63	420	0	0	**0.0**
Professional DJ System	130	33	97	420	230.9138844	230.9138844	**96.0**
Race car drive by	147	33	114	420	2437.541577	2437.541577	**113.0**
Refrigerator	50	33	17	420	0	0	**0.0**
Rifle	163	33	130	420	22400	22400	**129.0**
Riveting machine	110	33	77	420	0	0	**0.0**
Rock and roll concert	120	33	87	420	57.7284711	57.7284711	**86.0**
Scrapers	102	33	69	420	0	0	**0.0**
Sewing machine	60	33	27	420	0	0	**0.0**
Shotgun blast	140	33	107	420	923.6555375	923.6555375	**106.0**
Subway	115	33	82	420	28.86423555	28.86423555	**81.0**
Symphony orchestra	110	33	77	420	0	0	**0.0**
Traffic	85	33	52	420	0	0	**0.0**
Turbo fan aircraft at take-off power at 200 feet	118	33	85	420	43.75	43.75	**84.0**
Vacuum cleaner	70	33	37	420	0	0	**0.0**
Washing machine	75	33	42	420	0	0	**0.0**

(8+ hours without Hearing Protection)

Noisy Activity	Sound level dBA	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	480	102400	102400	140.0
Air conditioner	75	480	0	0	0.0
Ambulance siren	120	480	6400	6400	120.0
Backhoe	95	480	200	200	95.0
Belt sander	97	480	263.9015822	263.9015822	97.0
Blow dryer	95	480	200	200	95.0
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	480	918.958684	918.958684	106.0
Bomb/ grenade blast	191	480	120449752.6	120449752.6	191.0
Car horn	110	480	1600	1600	110.0
Car stereo		480	0	0	0.0
Car wash at 20 feet	89	480	87.05505633	87.05505633	89.0
Casino	80	480	25	25	80.0
CD Player on high	112	480	2111.212657	2111.212657	112.0
Chainsaw	120	480	6400	6400	120.0
Circular saw	100	480	400	400	100.0
City traffic	85	480	50	50	85.0
Conversation in a restaurant	60	480	0	0	0.0
Diesel train at 45 mph at 100 feet	83	480	37.892914 16	37.892914 16	83.0
Diesel truck going 40 mph at 50 feet	84	480	43.527528 16	43.527528 16	84.0
Dishwasher	80	480	25	25	80.0
Door bell	85	480	50	50	85.0
Drills	90	480	100	100	90.0
Drums	135	480	51200	51200	135.0
Dump truck	85	480	50	50	85.0
Electric drill	102	480	527.8031643	527.8031643	102.0
Electric shaver	80	480	25	25	80.0
Factory machinery	90	480	100	100	90.0
Farm tractor	100	480	400	400	100.0

Firecracker	**150**	**480**	**409600**	**409600**	**150.0**
Fireworks	**162**	**480**	**2161881.761**	**2161881.761**	**162.0**
Fire engine siren	**120**	**480**	**6400**	**6400**	**120.0**
Food blender	**88**	**480**	**75.78582833**	**75.78582833**	**88.0**
Football game	**117**	**480**	**4222.425314**	**4222.425314**	**117.0**
Freight train at 15 meters	**80**	**480**	**25**	**25**	**80.0**
Front end loader	**95**	**480**	**200**	**200**	**95.0**
Garbage disposal	**80**	**480**	**25**	**25**	**80.0**
Garbage truck	**100**	**480**	**400**	**400**	**100.0**
Grinders	**97**	**480**	**263.9015822**	**263.9015822**	**97.0**
Gunshot	**140**	**480**	**102400**	**102400**	**140.0**
Handgun	**166**	**480**	**3764054.77**	**3764054.77**	**166.0**
Helicopter at 100 feet	**100**	**480**	**400**	**400**	**100.0**
Jackhammer	**100**	**480**	**400**	**400**	**100.0**
Jet take-off at 25 meters	**150**	**480**	**409600**	**409600**	**150.0**
Jet take-off at 305 meters	**100**	**480**	**400**	**400**	**100.0**
Lawn mower	**100**	**480**	**400**	**400**	**100.0**
Leaf blower	**115**	**480**	**3200**	**3200**	**115.0**
Live rock music concert	**114**	**480**	**2785.761803**	**2785.761803**	**114.0**
Marching band	**130**	**480**	**25600**	**25600**	**130.0**
Maximum IPOD volume	**115**	**480**	**3200**	**3200**	**115.0**
Military jet aircraft take-off from aircraft carrier with afterburner at 50 feet	**130**	**480**	**25600**	**25600**	**130.0**
Milling machine	**85**	**480**	**50**	**50**	**85.0**
Mine blasting	**140**	**480**	**102400**	**102400**	**140.0**
Motorcycle	**100**	**480**	**400**	**400**	**100.0**
Motorcycle at 25 feet	**90**	**480**	**100**	**100**	**90.0**
MRI	**95**	**480**	**200**	**200**	**95.0**
Newspaper press	**97**	**480**	**263.9015822**	**263.9015822**	**97.0**
Night club	**110**	**480**	**1600**	**1600**	**110.0**
Oxygen torch	**121**	**480**	**7351.669472**	**7351.669472**	**121.0**
Pavers	**102**	**480**	**527.8031643**	**527.8031643**	**102.0**

Piano practice	**80**	**480**	**25**	**25**	**80.0**
Plumber	**90**	**480**	**100**	**100**	**90.0**
Pneumatic breakers	**111**	**480**	**1837.917368**	**1837.917368**	**111.0**
Power mower	**96**	**480**	**229.739671**	**229.739671**	**96.0**
Professional DJ System	**130**	**480**	**25600**	**25600**	**130.0**
Race car drive by	**147**	**480**	**270235.2201**	**270235.2201**	**147.0**
Refrigerator	**50**	**480**	**0**	**0**	**0.0**
Rifle	**163**	**480**	**2483350.023**	**2483350.023**	**163.0**
Riveting machine	**110**	**480**	**1600**	**1600**	**110.0**
Rock and roll concert	**120**	**480**	**6400**	**6400**	**120.0**
Scrapers	**102**	**480**	**527.8031643**	**527.8031643**	**102.0**
Sewing machine	**60**	**480**	**0**	**0**	**0.0**
Shotgun blast	**140**	**480**	**102400**	**102400**	**140.0**
Subway	**115**	**480**	**3200**	**3200**	**115.0**
Symphony orchestra	**110**	**480**	**1600**	**1600**	**110.0**
Traffic	**85**	**480**	**50**	**50**	**85.0**
Turbo fan aircraft at take-off power at 200 feet	**118**	**480**	**4850.293013**	**4850.293013**	**118.0**
Vacuum cleaner	**70**	**480**	**0**	**0**	**0.0**
Washing machine	**75**	**480**	**0**	**0**	**0.0**

(8+ hours with Hearing Protection NRR 33)

Noisy Activity	Sound level dBA	Hearing Protection NRR	Sound level dBA with HP	Exposure time in minutes	% Dose per source	Total accumulated dose	Calculated TWA dBA
Aircraft carrier deck	140	33	107	480	1055.606329	1055.606329	**107.0**
Air conditioner	75	33	42	480	0	0	**0.0**
Ambulance siren	120	33	87	480	65.975395544	65.975395544	**87.0**
Backhoe	95	33	62	480	0	0	**0.0**

Belt sander	97	33	64	480	0	0	**0.0**
Blow dryer	95	33	62	480	0	0	**0.0**
Boeing 707 or DC-9 aircraft 6087 feet before landing	106	33	73	480	0	0	**0.0**
Bomb/ grenade blast	191	33	158	480	1241675.011	1241675.011	**158.0**
Car horn	110	33	77	480	0	0	**0.0**
Car stereo		33	-33	480	0	0	**0.0**
Car wash at 20 feet	89	33	56	480	0	0	**0.0**
Casino	80	33	47	480	0	0	**0.0**
CD Player on high	112	33	79	480	0	0	**0.0**
Chainsaw	120	33	87	480	65.97539554	65.97539554	**87.0**
Circular saw	100	33	67	480	0	0	**0.0**
City traffic	85	33	52	480	0	0	**0.0**
Conversation in a restaurant	60	33	27	480	0	0	**0.0**
Diesel train at 45 mph at 100 feet	83	33	50	480	0	0	**0.0**
Diesel truck going 40 mph at 50 feet	84	33	51	480	0	0	**0.0**
Dishwasher	80	33	47	480	0	0	**0.0**
Door bell	85	33	52	480	0	0	**0.0**
Drills	90	33	57	480	0	0	**0.0**
Drums	135	33	102	480	527.8031643	527.8031643	**102.0**
Dump truck	85	33	52	480	0	0	**0.0**
Electric drill	102	33	69	480	0	0	**0.0**
Electric shaver	80	33	47	480	0	0	**0.0**
Factory machinery	90	33	57	480	0	0	**0.0**
Farm tractor	100	33	67	480	0	0	**0.0**
Firecracker	150	33	117	480	4222.425314	4222.425314	**117.0**

Fireworks	162	33	129	480	22286.09442	22286.09442	**129.0**
Fire engine siren	120	33	87	480	65.97539554	65.97539554	**87.0**
Food blender	88	33	55	480	0	0	**0.0**
Football game	117	33	84	480	43.52752816	43.52752816	**84.0**
Freight train at 15 meters	80	33	47	480	0	0	**0.0**
Front end loader	95	33	62	480	0	0	**0.0**
Garbage disposal	80	33	47	480	0	0	**0.0**
Garbage truck	100	33	67	480	0	0	**0.0**
Grinders	97	33	64	480	0	0	**0.0**
Gunshot	140	33	107	480	1055.606329	1055.606329	**107.0**
Handgun	166	33	133	480	38802.3441	38802.3441	**133.0**
Helicopter at 100 feet	100	33	67	480	0	0	**0.0**
Jackhammer	100	33	67	480	0	0	**0.0**
Jet take-off at 25 meters	150	33	117	480	4222.425314	4222.425314	**117.0**
Jet take-off at 305 meters	100	33	67	480	0	0	**0.0**
Lawn mower	100	33	67	480	0	0	**0.0**
Leaf blower	115	33	82	480	32.98769777	32.98769777	**82.0**
Live rock music concert	114	33	81	480	28.71745887	28.71745887	**81.0**
Marching band	130	33	97	480	263.9015822	263.9015822	**97.0**
Maximum IPOD volume	115	33	82	480	32.98769777	32.98769777	**82.0**
Military jet aircraft take-off from aircraft carrier with afterburner at 50 feet	130	33	97	480	263.9015822	263.9015822	**97.0**
Milling machine	85	33	52	480	0	0	**0.0**

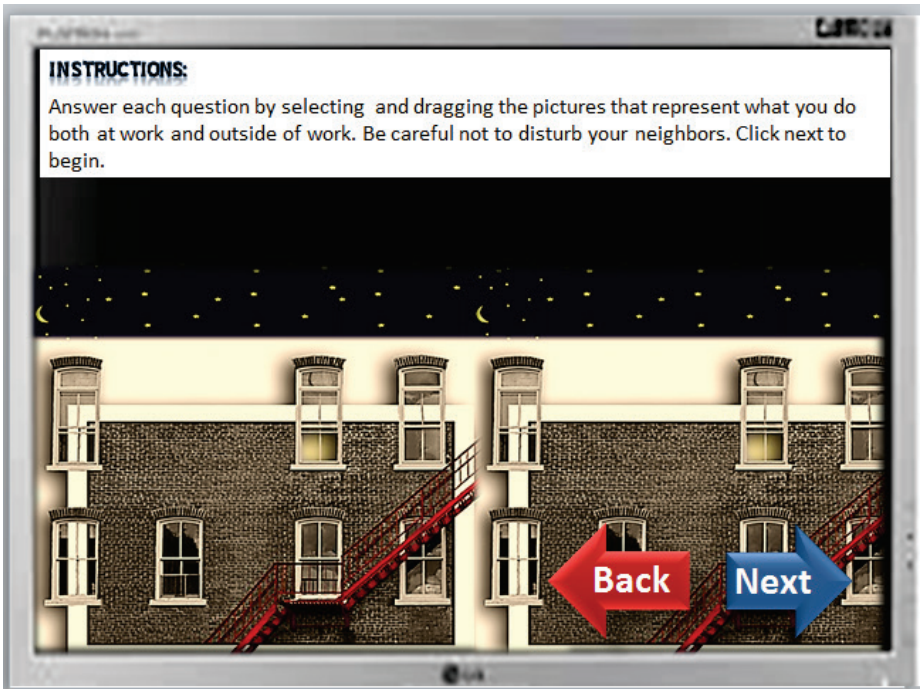
Mine blasting	140	33	107	480	1055.606329	1055.606329	**107.0**
Motorcycle	100	33	67	480	0	0	**0.0**
Motorcycle at 25 feet	90	33	57	480	0	0	**0.0**
MRI	95	33	62	480	0	0	**0.0**
Newspaper press	97	33	64	480	0	0	**0.0**
Night club	110	33	77	480	0	0	**0.0**
Oxygen torch	121	33	88	480	75.78582833	75.78582833	**88.0**
Pavers	102	33	69	480	0	0	**0.0**
Piano practice	80	33	47	480	0	0	**0.0**
Plumber	90	33	57	480	0	0	**0.0**
Pneumatic breakers	111	33	78	480	0	0	**0.0**
Power mower	96	33	63	480	0	0	**0.0**
Professional DJ System	130	33	97	480	263.9015822	263.9015822	**97.0**
Race car drive by	147	33	114	480	2785.761803	2785.761803	**114.0**
Refrigerator	50	33	17	480	0	0	**0.0**
Rifle	163	33	130	480	25600	25600	**130.0**
Riveting machine	110	33	77	480	0	0	**0.0**
Rock and roll concert	120	33	87	480	65.97539554	65.97539554	**87.0**
Scrapers	102	33	69	480	0	0	**0.0**
Sewing machine	60	33	27	480	0	0	**0.0**
Shotgun blast	140	33	107	480	1055.606329	1055.606329	**107.0**
Subway	115	33	82	480	32.98769777	32.98769777	**82.0**
Symphony orchestra	110	33	77	480	0	0	**0.0**
Traffic	85	33	52	480	0	0	**0.0**
Turbo fan aircraft at take-off power at 200 feet	118	33	85	480	50	50	**85.0**

Vacuum cleaner	70	33	37	480	0	0	**0.0**
Washing machine	75	33	42	480	0	0	**0.0**

(These calculations were adapted from the Driscoll Sound Dosage Scale. See references.)

Appendix C

HSCSNAP Demo




Which of these tasks most closely resembles what you do at work? (You may select more than one).
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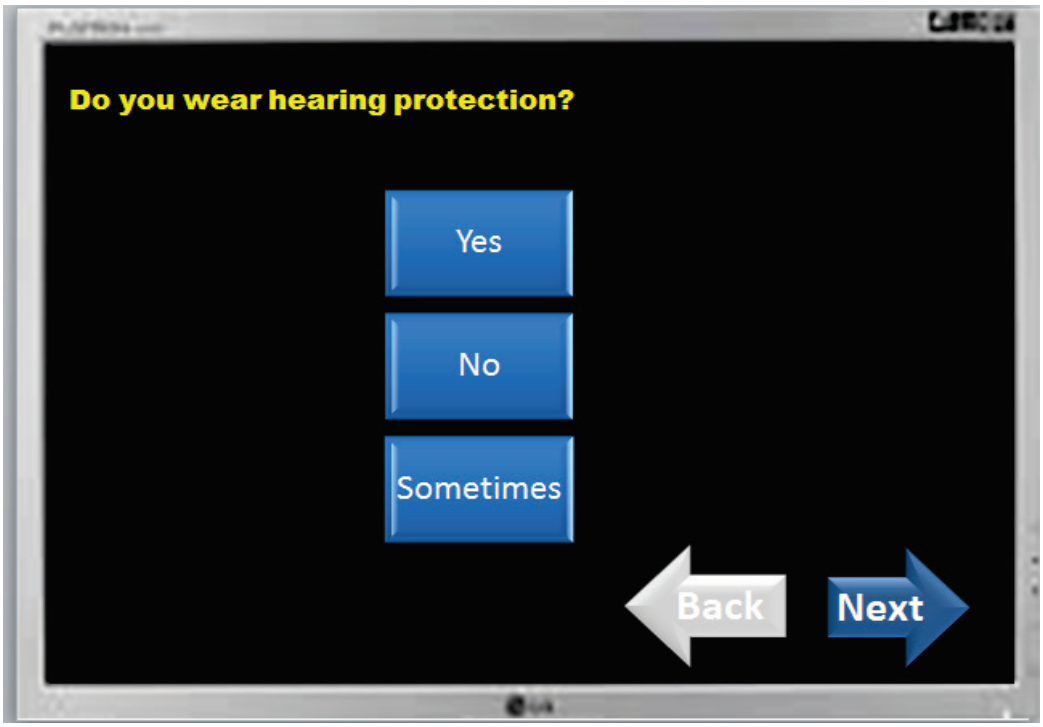
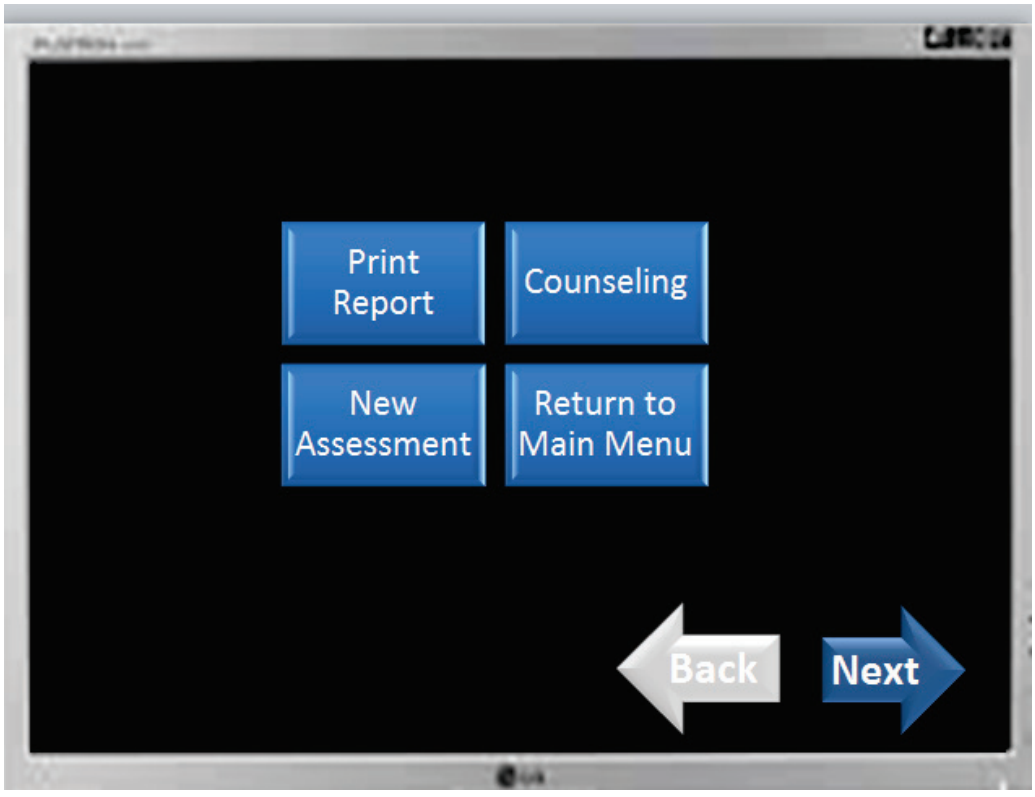

Do you wear hearing protection?
Yes
No
Sometimes
Back
Next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